Claims

1. An apparatus for correcting sine magnification error in a multiple aperture optical system, comprising:

an optical element disposed substantially at an image generated by the optical system.

2. An apparatus according to claim 1, wherein the optical element is one of a refractive element, a reflective element, and a diffractive element.

3. An apparatus according to claim 1, wherein the optical element has substantially no optical power.

4. An apparatus according to claim 1, wherein the optical system includes a fold flat mirror having a perforation, and the optical element is disposed within the perforation of the fold flat mirror.

5. An apparatus according to claim 1, wherein the optical system is a three mirror anastigmat telescope.

6. An apparatus according to claim 1, wherein the image is an intermediate image.

7. An apparatus according to claim 1, wherein the optical element is a refractive element having a flat surface and a corrector surface.

8. An apparatus according to claim 7, wherein the corrector surface is defined by a rotationally symmetric polynomial.

9. An apparatus according to claim 8, wherein the polynomial is of the general form

$$z = \frac{cy^2}{1+\sqrt{1-(k+1)c^2y^2}} + Dy^4 + Ey^6 + Fy^8 + Gy^{10}$$

where z is the departure from a plane, and y is the radial coordinate on the surface, D, E, F, G, C and K are parameters which are varied during the design process to minimize the sine magnification error and represent aspheric coefficients, c is a vertex curvature and k is a conic constant.

10. An apparatus according to claim 1, wherein the optical element is on or within about 50 millimeters of an intermediate image for an 8 meter diameter collector.

11. An apparatus according to claim 10, wherein the optical system has a 44.6 meter encircling diameter.

12. An apparatus according to claim 1, wherein the optical element comprises a plurality of lenses to achieve the sine magnification correction and a combined near zero optical power, and no aspheric surfaces.

13. An apparatus according to claim 12, wherein the plurality of lenses includes a negative lens disposed in juxtaposition to a positive lens.

14. An apparatus according to claim 13, wherein the negative lens and the positive lens each has a planar surface.

15. A method of reducing sine magnification error in a multiple aperture optical system comprising the steps of:

tracing a plurality of chief rays from a plurality of different field points;

computing a fractional sine magnification error for each traced chief ray; and

varying the surface shape parameters, and a position of a corrector element relative to an intermediate image of the optical system to globally minimize the squares of the computed fractional sine errors.

16. A method according to claim 15, wherein the varying step includes

varying a corrective surface of the corrector element according to the polynomial

$$z = \frac{cy^2}{1+\sqrt{1-(k+1)c^2y^2}} + Dy^4 + Ey^6 + Fy^8 + Gy^{10}$$

where z is the departure from a plane, and y is the radial coordinate on the surface, D, E, F, G, C and K are parameters which are varied during the design process to minimize the sine magnification error, and represent aspheric coefficients, c is a vertex curvature and k is a conic constant.

17. A method according to claim 15, wherein the varying step includes maintaining a maximum allowable phase error "p" for a distributed aperture system of baseline L so that the fractional sine magnification errors sk satisfy the equation $sk \leq \dfrac{p}{L\sin(a_{ik})}$ for every point in the field of view.

18. A multiple aperture optical system comprising:

a plurality of collector telescopes, each forming an image;

and

a plurality of optical elements disposed respectively at or near the iimages, each having a surface adapted to correct sine magnification error.

19. A multiple aperture optical system according to claim 18, wherein each image is an intermediate image.

20. A multiple aperture optical system according to claim 18, wherein each optical element is at or within about 50 millimeters of the image for collectors up to 8 meter diameter.

21. A multiple aperture optical system according to claim 18, wherein each optical element is one of a refractive element, a reflective element, and a diffractive element.

22. A multiple aperture optical system according to claim 18, wherein the plurality of optical elements have substantially no optical power.

23. A multiple aperture optical system according to claim 18, further comprising a plurality of fold flat mirrors, each having a perforation, and being disposed in an optical path near the perforation of the primary reflector, a plurality of tertiary reflectors, each positioned to reflect light passing through the perforation of the fold flat back to the fold flat mirror, and wherein each optical element is disposed within the perforation of each respective fold flat mirror.

24. A multiple aperture optical system according to claim 18, wherein the correcting element optical element is a refractive element having a flat surface and a correcting element.

25. A multiple aperture optical system according to claim 24, wherein the corrector surface is defined by a rotationally symmetric polynomial.

26. A multiple aperture optical system according to claim 25, wherein the polynomial is of

the general form

$$z = \frac{cy^2}{1+\sqrt{1-(k+1)c^2y^2}} + Dy^4 + Ey^6 + Fy^8 + Gy^{10}$$

where z is the departure from a plane, and y is the radial coordinate on the surface, D, E, F, G, C and K are parameters which are varied during the design process to minimize the sine magnification error and represent aspheric coefficients, c is a vertex curvature and k is a conic constant.

27. A multiple aperture optical system according to claim 18, wherein each of the plurality of optical elements comprises a plurality of lenses having a combined near zero optical power, and no aspheric surfaces.

28. A multiple aperture optical system according to claim 27, wherein the plurality of lenses includes a negative lens disposed in juxtaposition to a positive lens.

29. A multiple aperture optical system according to claim 28, wherein at least one of the negative and positive lenses includes a planar surface.

30. A method of correcting sine magnification error in a multiple aperture optical system comprising the steps of:

placing a correcting element substantially at or near an image formed by the optical system.

31. A method according to claim 30, wherein the placing step comprises placing an optical element substantially at or near an intermediate image formed by the optical system.

32. A method according to claim 30, wherein the placing step comprises placing a non-optically powered optical element substantially at or near an intermediate image formed by the optical system.

33. A method according to claim 32, wherein the placing step comprises placing a plurality of lenses at or near an intermediate image formed by the the

optical system, wherein the lenses have a combined near zero optical power, and no aspheric surface.